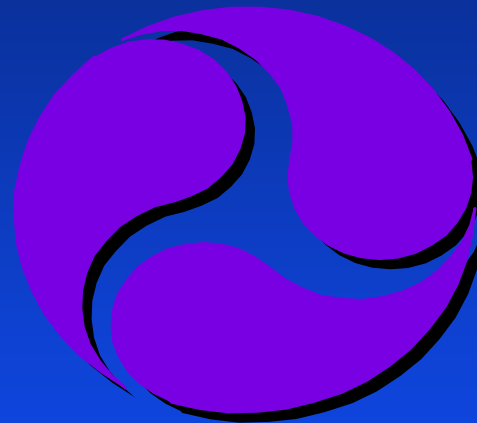


Road Surface Analyzer (ROSANTM) MGPS Surface



Brad Neitzke
Materials Engineer
Western Federal Lands Highway Division

FHWA Federal Lands Highway



ROSAN_{TM}

- A laser-based profiler using an accelerometer established inertial reference.
- ROSAN_{TM} was originally developed by the Turner Fairbank Highway Research Center in private partnership with Surfan Engineering and Software, Inc., now known as MGPS Surface, Inc.
- ROSAN_{TM} measures texture and longitudinal pavement profile at highway speeds.



Capabilities

- Texture Analysis - Determination of Mean Profile Depth (MPD) using ROSAN_{TM} or ASTM E 1845 methods.
- Smoothness Analysis - Simulation of California Profilograph [Profile Index (PI)], using ASTM E 950 & FLH T 504.
- Roughness Analysis - Determination of International Roughness Index (IRI) & Ride Number (RN), using ASTM E 950 & E 1926.





Components

- Laser
- Optocator Interface
- Accelerometer
- Pulser
- Computer



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Portability



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Mounting (Exterior)

- ROSAN_{TM} – Mounts on any vehicle with a step bumper.



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Mounting (Interior)



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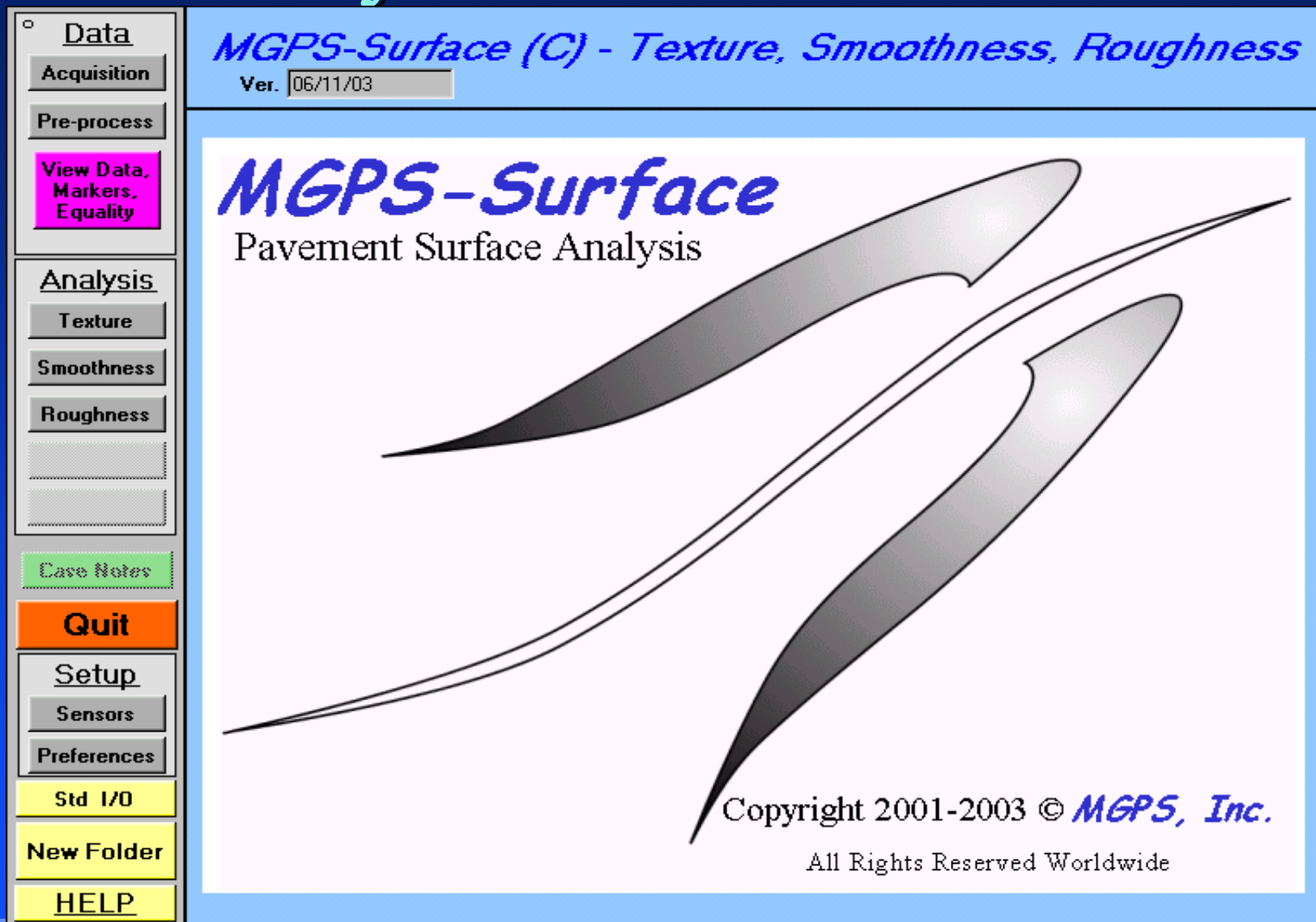
Data Acquisition

- Capable of sample intervals ranging from 0.25 mm to 25.0 mm.
- Capable of sampling at speeds ranging from 15 mph to 70 mph (sample interval dependent).
- Usually, no traffic control required, due to sampling speed capability.





Introductory Screen



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Setup Screen

Data
Acquisition
Pre-process
View Data, Markers, Equality
Analysis
Texture
Smoothness
Roughness
Case Notes
Quit
Setup
Sensors
Preferences
Std I/O
New Folder
HELP

MGPS-Surface (C) - Texture, Smoothness, Roughness
Ver. 06/11/03
Pulser (DMI) Calibration/Test
☒ Short 500.00 Feet
☒ Dist. 152.40 Meters
☐ Long 0.00 Feet
☐ Dist. 0.00 Meters
Vehicle 55.00 Mph
Speed 88.51 Kph
Physical Marker
Dimensions for Short
Height 37.00 mm
Width 150.00 mm
Marker Type
☐ Physical
☐ Optical
Acquire Data
Scans 0
Pulses 0
Distance (Ft) 0.000
Find Markers (Short Dist)
1st 0
2nd 0
Trial Pulse (mm)
☐ 0.0000
☐ 0.0000
☐ 0.0000
☐ 0.0000
☐ 0.0000
Mean 0.0000
Save

Laser Channel
1
Calibrate Laser
Calibrate Accelerometer
Laser Parameters
Accelerometer Parameters
Sample All Channels then Plot Voltages





Data Acquisition Screen

Data

Acquisition

Pre-process

View Data, Markers, Equality

Analysis

Texture

Smoothness

Roughness

Case Notes

Quit

Setup

Sensors

Preferences

Std I/O

New Folder

HELP

MGPS-Surface (C) - Texture, Smoothness, Roughness

Ver. 06/11/03

Casename

Site

Interval

DAQ Speed

Application(s)

Print Case File

DAQ OFF

Date Time

Auto No. Casename Sequence

Initialize DAQ

Real-Time Display ON

Configuration

Laser ☐ ☒ ☐

Left Center Right

Accelerometer (Left, Center, or Right) ☐ ☒ ☐

Optical Sensor OFF

Vehicle ☐ Subaru ☐ Other

Lane Number

L 6 5 4 3 2 1 0 R

Pavement Type

Concrete - ☐

Asphaltic Concrete - ☒

Asphalt Overlay - ☐

Other, See Notes - ☐

Temperature

Pavement	Air	
<input type="text" value="60.1"/>	<input type="text" value="60.1"/>	F
<input type="text" value="15.6"/>	<input type="text" value="15.6"/>	C

Surface Treatment

None - ☐

Grooved, Transverse - ☐

Grooved, Longitudinal - ☐

Diamond Ground - ☐

Fixed Pitch Tining - ☐

Random Pitch Tining - ☐

Open Graded Asphalt - ☐

Slurry Seal - ☐

Skidabrator (tm) - ☐

Other, See Notes - ☐

GPS Recording OFF

Start of Data Acquisition

Latitude (N)	Longitude (W)
<input type="text" value="0.0000"/>	<input type="text" value="0.0000"/>
<input type="text" value="0.0000"/>	<input type="text" value="0.0000"/>

Lat/Long Snapshot

Ref. Post

Profiler ID

S/N

Operator

Get Default Info

Save as Default Info

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Pre-Process Screen

Data

Acquisition

Pre-process

View Data, Markers, Equality

Analysis

Texture

Smoothness

Roughness

Case Notes

Quit

Setup

Sensors

Preferences

Std I/O

New Folder

HELP

MGPS-Surface (C) - Texture, Smoothness, Roughness

Ver. 06/11/03

Casename Mannassas_Test_2 Date 11-20-2003 Time 11:29:12

Data Direction

☒ Reversed

☒ As Collected

☒ Texture

Raw ☒

Temporal ☒ ☒ ☒

Spatial ☒ ☒

Mean Profile Depth ☒

☒ Smoothness*

Raw ☒

Temporal ☒ ☒ ☒

Spatial ☒ ☒

Profile ☒

Profilograph Span (ft) 25

Type California

Filter Length (ft) 1.875

Flattened Profile ☒

☒ Roughness*

Raw ☒

Temporal ☒ ☒ ☒

Spatial ☒ ☒

Profile (& Tire, 25mm) ☒ ☒ ☒

Longwave Filter 61.0 m 200.0 Ft

Profile Analysis Interval

☐ 125 mm ☒ ☒ ☒

☐ 152.4 mm (.5ft) ☒ ☒ ☒

☐ 304.8 mm (1ft) ☒ ☒ ☒

☒ .User 101.60 mm ☒ ☒ ☒

Temporal Scans

295680

Measured Distance

289.04 M

948.28 FT

0.289 KM

0.180 MI

Show Gs Off

Progress Indicator %

Pre-Process Data

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

* Accelerometer(s) required for Smoothness and Roughness

Show Events

Print Events

Show Optical

Print Optical

Show GPS

Print GPS

Delete Intermediate Files



Texture Analysis Screen

Data

Acquisition

Pre-process

View Data, Markers, Equality

MGPS-Surface (C) - Texture, Smoothness, Roughness

Ver. 06/11/03

Casename

Mannassas_Test_2

Do Texture Analysis

Segment Length 528.00 Feet

Do shape Analysis

Window Length 500 Points

Bins 40

Aggregate Segregation in HMA [AASHTO]

19.00	Max Agg Size mm	Predicted ETD
0.170	D10	0.40 mm
1.180	D30	
5.000	D60	
1.638	Cc	
29.412	Cu	

Segregation Limits (mm)

None Lower	0.28
None Upper	0.46
Low Upper	0.63
Med. Upper	0.81

Plot Type

☒ Chart

☐ Histogram

☐ PSD

☐ Shape 10

Plot Selection

☐ ROSAN

☒ ASTM

Plot

ETD

Show Segregation Info (ETD & Metric)

English Units

Segregation All	Below None	0.0	None	0.0	Low	0.0	Medium	0.0	High	0.0
Levels Window	Below None	0.0	None	0.0	Low	0.0	Medium	0.0	High	0.0

Active Cursor: X 0.000 Y 0.000 Ref (ft) 0.000 Ref (m) 0.000

Zoom **Restore**

ROSAN Mn 0.037 Med 0.036 SD 0.006

Total Length 948.28 Begin 0.00 Span to Plot 948.28

Feet

ASTM Mn 0.039 Med 0.038 SD 0.005

Plot

Prev Next

Show ASTM Report

Show ROSAN Report

Print Case File

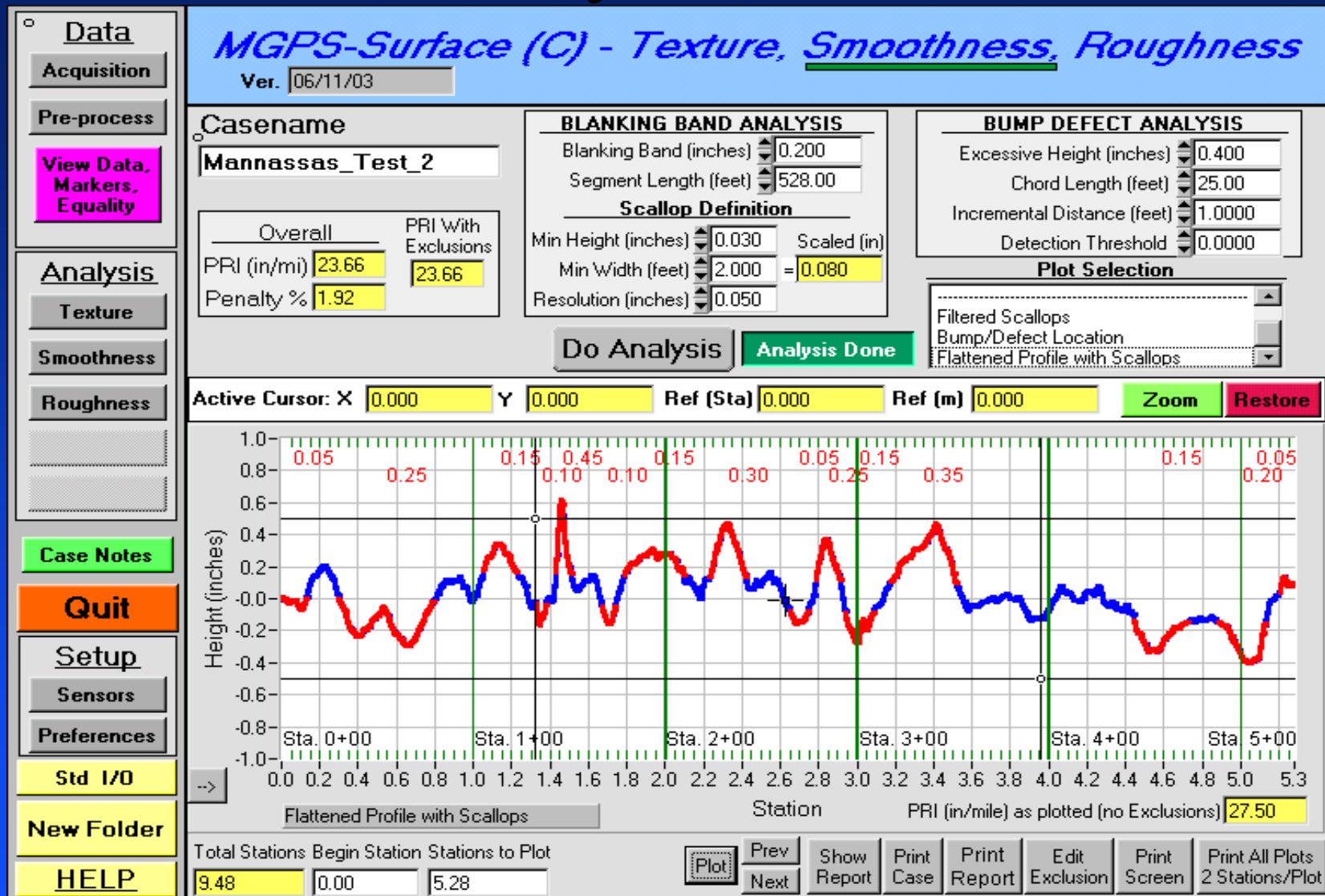
Print Reports

Edit Exclusions

Print Texture Window

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Smoothness Analysis Screen



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Roughness Analysis Screen (IRI)

MGPS-Surface (C) - Texture, Smoothness, Roughness
Ver. 06/11/03

Data
Acquisition
Pre-process
View Data, Markers, Equality

Analysis
Texture
Smoothness
Roughness
Case Notes
Quit
Setup
Sensors
Preferences
Std I/O
New Folder
HELP

Casename
Mannassas_Test_2

Interval(s) base, Roughness analysis (grey = not present)
☐ 125 mm
☐ 152.4 mm (0.5 ft)
☐ 304.8 mm (1.0 ft)
☒ 101.6 mm

Do IRI & RN Analysis

Plot Type
☒ IRI
☐ RN
☐ Profile
☐ PSD

Interval base for Plotting
☐ 125 mm
☐ 152.4 mm
☐ 304.8 mm
☒ User

English Units

Plot

Roughness
Moving Average
Base Window ☐ **Left** ☒ **Center** ☐ **Right**
Detail Window ☐ ☒
Base 528.0 ft Detail 30.0 ft
Threshold 149.97 in/mile

Active Cursor: X 0.000 Y 0.000 Ref (ft) 0.000 Ref (m) 0.000 **Zoom** **Restore**

IRI

IRI L, C, R 0.000 134.612 0.000 in/mile Distance RN (PSI) L,C,R 9.99 3.12 9.99

Total Length 947.67 Begin 0.00 Span to Plot 528.00 **Plot** **Prev** **Next** **Print Plot** **Show Report** **Print Report** **Print Case** **Edit Exclusions** **Create ERD files** **Create TX files**

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System Performance Verification

- Each FLH Division evaluated ROSAN_{TM} against the California Profilograph by performing 10 traces with both over a 1 mile section.
- The three FLH Divisions met at Mn/Road Test Facility to determine precision and bias for the ROSAN_{TM} system.
 - ◆ Over 216 longitudinal profiles were taken to evaluate: operators, data acquisition speed, and vehicle type.
- Evaluated repeatability at different data acquisition intervals and speeds.



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Testing at Mn/Road Test Facility



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Results of System Evaluation

- Texture module was not evaluated under this work plan. Future plans to evaluate.
- Smoothness module (PI) was found to need revision.
 - ◆ Revision required for different manufacturers.
- Roughness module (IRI).
 - ◆ Operator variability was found to be insignificant.
 - ◆ Variability related to speed and vehicle type.
 - ◆ Accelerometer concerns surfaced.



Current Status

- Revisions made to accommodate different manufacturer system configurations for smoothness.
- Problems with speed and vehicle dependency resolved & all FLH units have passed Certification requirements.
- Accelerometer Tree Study has been completed. New accelerometers installed.
- Data collection to validate and refine the new roughness specification adopted for the FP-03 is continuing.

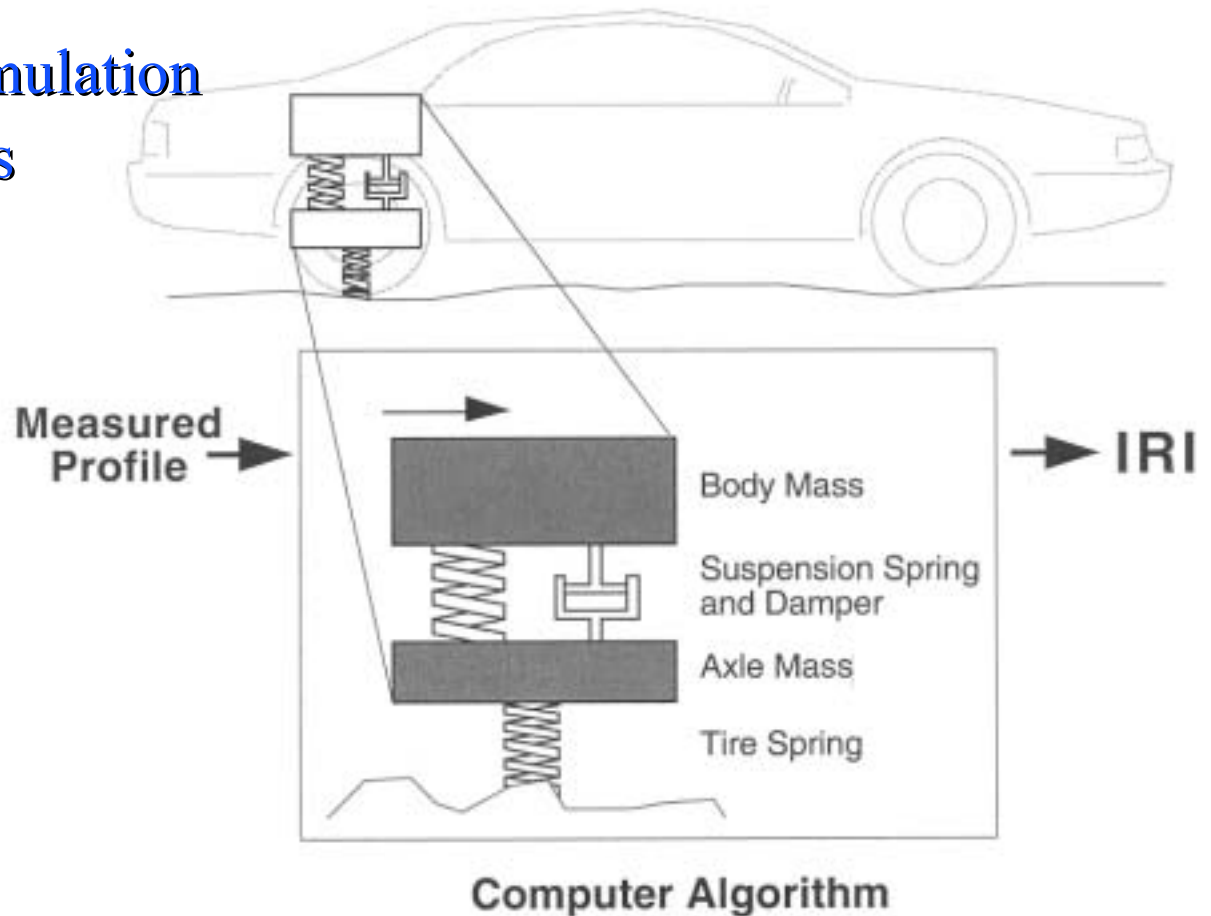




Current Status (continued)

➤ WFLHD Roughness Specification

- ◆ Based on IRI
- ◆ Quarter Car Simulation
- ◆ New Pavements
- ◆ Overlays





Current Status (continued)

➤ WFLHD Roughness Specification – new pavement

Table 401-3	
Type III Pavement Roughness	
IRI (inches per mile)	Pay Adjustment Factor (PAF)
Less than 30.0	PAF = 12.500
30.0 to 59.9	PAF = $25 - 0.4167 (\text{IRI})$
60.0 to 65.0	PAF = 0.00
65.1 to 95.0	PAF = $81.25 - 1.25 (\text{IRI})$
Greater than 95.0	Rejected ⁽¹⁾

(1) Pay adjustment factor when corrections are not allowed equals minus 37.50.

Current Status (continued)

➤ WFLHD Roughness Specification – overlays

Table 401-4 Type IV Pavement Roughness			
Single Lift ⁽¹⁾ Percent Improvement (%)	Pay Adjustment Factor ⁽¹⁾	Multi-Lift ⁽²⁾ Percent Improvement (%)	Pay Adjustment Factor ⁽²⁾
Greater than 48.4	PAF = 12.50	Greater than 61.1	PAF = 12.50
24.8 to 48.4	PAF = 0.5274(%) - 13.027	43.3 to 61.1	PAF = 0.6983(%) - 30.168
12.4 to 24.7	PAF = 0.00	34.0 to 43.2	PAF = 0.00
0.9 to 12.3	PAF = 13.209(%) - 40.435	25.4 to 33.9	PAF = 4.3805(%) - 148.280
Less than 0.9	Reject ⁽³⁾	Less than 25.4	Reject ⁽³⁾

- (1) For single lift overlays with no other corrective work such as milling, grinding or preleveling in excess of 25 percent of the surface area the of existing pavement.
- (2) For multiple lift operations such as milling, grinding or preleveling followed by one or more lifts of pavement or two or more lifts of pavement without milling, grinding or preleveling.
- (3) Pay adjustment factor when corrections are not allowed equals minus 37.5.





Current Status (continued)

■ AASHTO has adopted 4 provisional standards:

- ◆ MP 11-03, Standard Equipment Specification for Inertial Profiler
- ◆ PP 49-03, Standard Practice for Certification of Inertial Profiling Systems
- ◆ PP 50-03, Standard Practice for Operating Inertial Profilers and Evaluating Pavement Profiles
- ◆ PP 51-03, Standard Practice for Pavement Ride Quality when Using Inertial Profile Systems



System Performance Verification

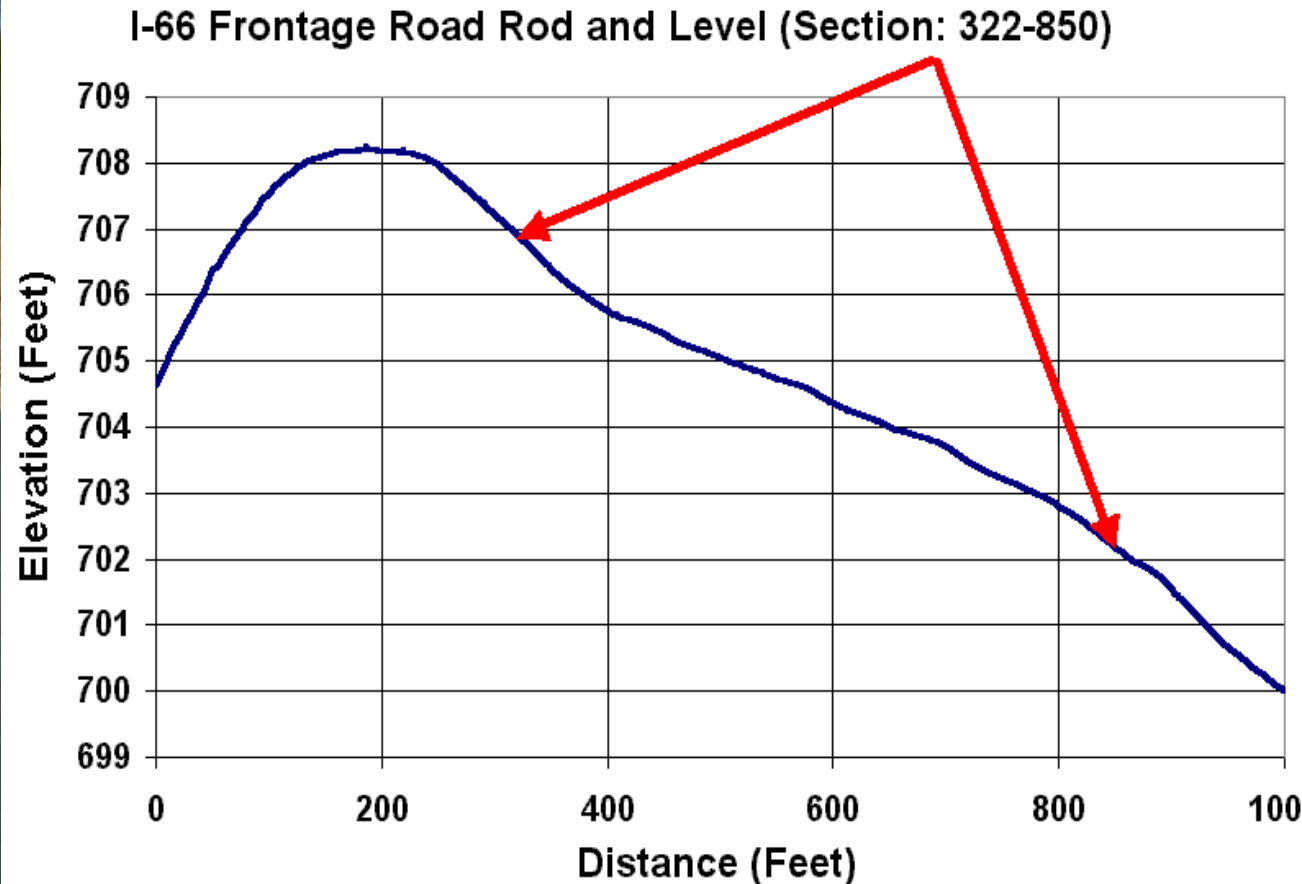
➤ Texas Certification



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System Performance Verification

Medium Smooth Site – Virginia



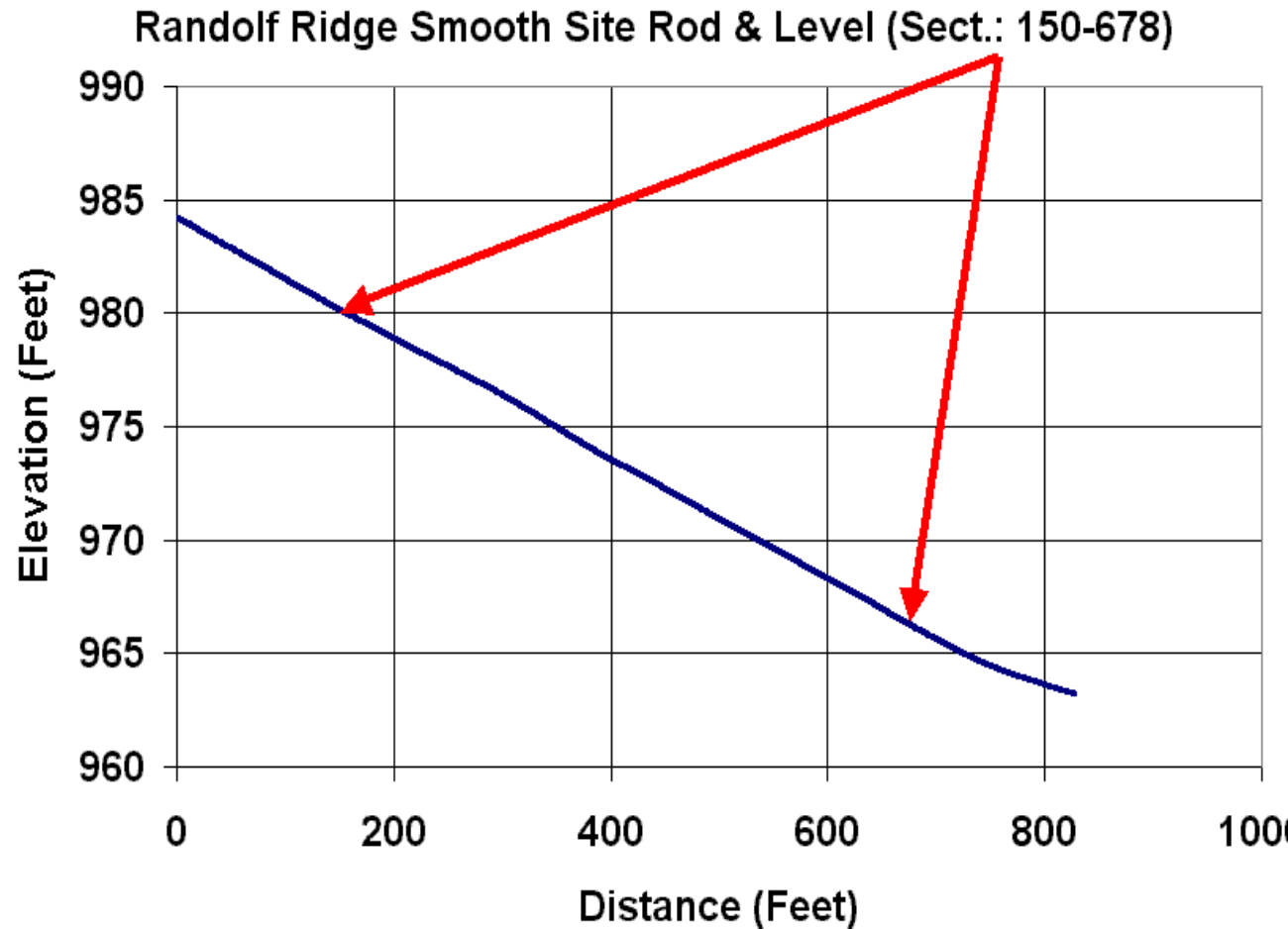
➤ AASHTO PP 49-03 IRI = 132 in/mile

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System Performance Verification

Smooth Site - Virginia



➤ AASHTO PP 49-03 IRI = 83 in/mile

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Other Systems

- Approximately two dozen different Inertial Profilers available.



Profilograph



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Ames Engineering - LISA



FHWA Federal Lands Highway

International Cybernetics Corp. - Mule



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Surface Systems & Instruments - LWP



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Surface Systems & Instruments – Full Size



FHWA Federal Lands Highway

KJ Law\Dynatest - LP



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Dynatest – Full Size



FHWA Federal Lands Highway

Roadware – Full Size



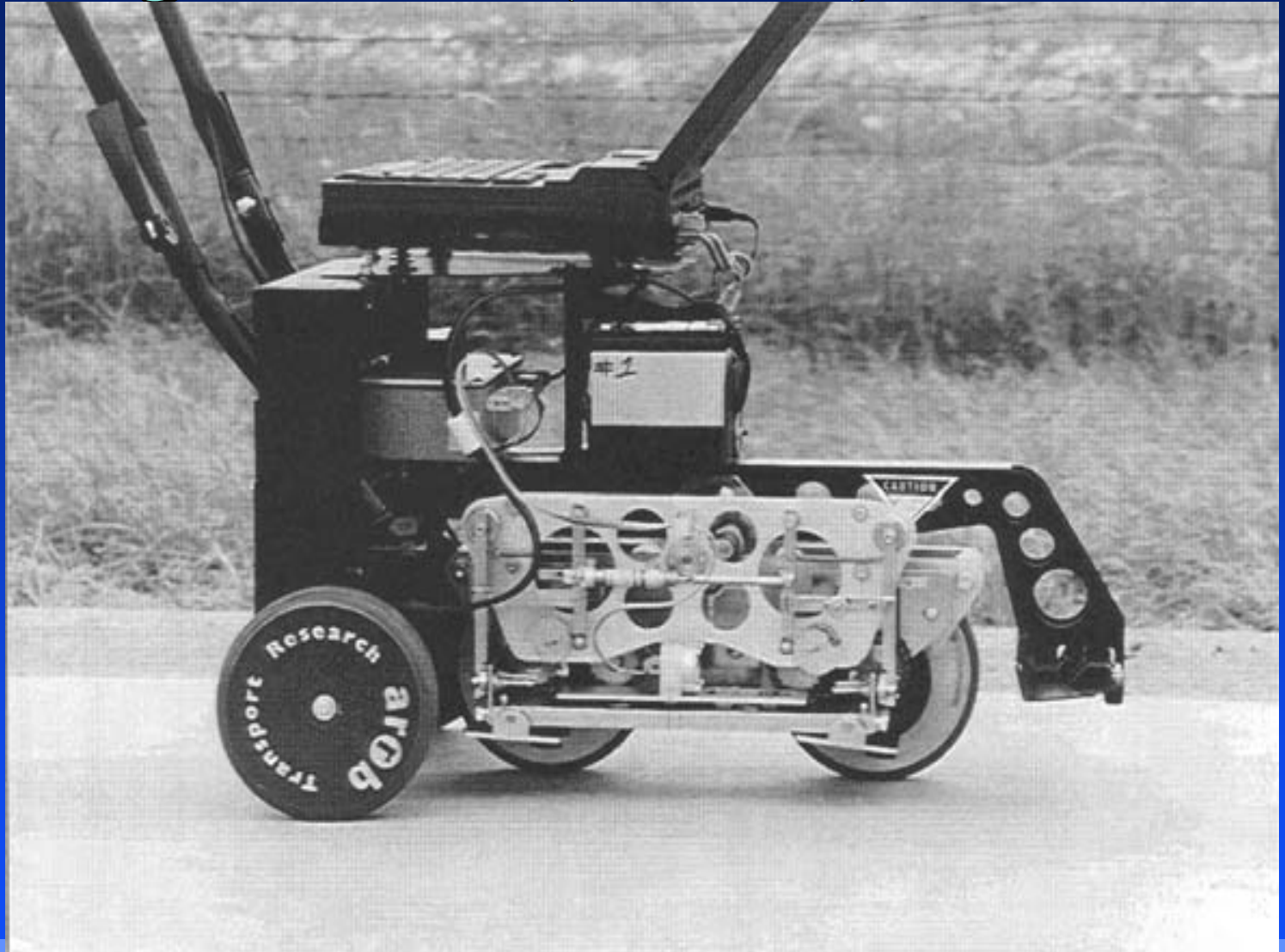
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Infrastructure Management Services (IMS)



FHWA Federal Lands Highway

Walking Profiler (ARRB)



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MGPS Surface (ROSAN_{TM})



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Available Resources

- FP-03 specification change info
- HMA Pavement Smoothness Publication
- “The Little Book of Profiling”

